New Trajectory Planner for Higher Elevation Landing

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A goal of Mars Entry, Descent and Landing (EDL) technology development is landing at higher elevation sites. Previous Mars landers have landed at sites with elevations below -1.4 km MOLA (Mars Orbiter Laser Altimeter). To reach much of the Ancient Highlands, the majority of the southern hemisphere, requires landing at elevations as high as +3 km MOLA. The entry guidance system has to deliver the lander accurately to the supersonic parachute deployment point within the parachute altitude, dynamic pressure, and Mach number constraints. The higher the required landing site elevation is, the lower the atmospheric density is that the lander must maneuver in during the final stage of entry and thus the lower the lift the vehicle can use to change the flight path.

In previous work, the Evolved Acceleration Guidance Logic for Entry (EAGLE), originally designed for Reusable Launch Vehicles with high lift-to-drag (L/D) ratio, has been adapted for low L/D vehicles. EAGLE is composed of trajectory planning and a trajectory tracking algorithms. It plans and tracks a drag acceleration profile, which makes EAGLE robust to modeling errors. This paper describes a new planning algorithm intended to enable guidance of low L/D vehicles to higher final altitudes.

Initially, this paper addresses the definition of the deployment altitude control authority. Based on the definition, trajectories that have a high control authority and a high deployment altitude are characterized. Increased control authority will allow a reduction in the deployment errors in the presence of aerodynamic and atmospheric uncertainties.

The second part of this paper presents the development of a new trajectory planning algorithm. The new planner is inspired by optimal trajectories that have the characteristics described previously in the paper. The resulting planner generates feasible trajectories that deploy the parachute on the desired deployment point at high altitude and high control authority.

Finally, two planning algorithms, the new one and a previously developed one are described, tested and performances are compared by implementing them in EAGLE. A Mars Science

Laboratory (MSL)-like capsule model has been used. The same trajectory tracking algorithm is used to follow the reference trajectories generated by each planner in a 500 cases Monte-Carlo simulation. Each 500 cases distinguish from the others in the initial condition and in the aerodynamic and atmospheric uncertainties. These uncertainties are significantly different from the nominal values. Results show that the new planner improves the final horizontal accuracy, reduces both horizontal and altitude dispersion keeping a high final altitude.